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ELECTRIC UTILITY
ORIENTATION PROGRAM

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SOUTHERN CALIFORNIA EDISON COMPANY

BUREAU OF LAND MANAGEMENT
BARSTOW RESOURCE AREA
Barstow, California
April 15, 1982

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AGENDA
ELECTRIC UTILITY ORIENTATION PROGRAM

Location: Needles (Pacific Federal Bank), Wednesday, March 17, 1982
Barstow (Fire Station), Thursday, April 15, 1982
Riverside (Riverside Inn), Thursday, May 6, 1982
Sacramento (State Office), Wednesday, May 26, 1982

Subject	Time Period
I. Introduction	8:30 - 8:45 a.m.
II. Planning	8:45 - 10:00 a.m.
A. Load Forecast/Load Management	
B. Generation Planning	
C. Transmission Planning	
D. Questions & Answers	
III. Break	10:00 - 10:15 a.m.
IV. Transmission Line Route & Selection	10:15 - 11:15 a.m.
A. Operating Environment	
B. Route Selection Process	
C. Feasbility Studies	
D. Questions & Answers	
V. System Reliability (Slide Presentation)	11:15 - 12:00 p.m.
A. Questions & Answers	
LUNCH	12:00 - 1:00 p.m.
VI. Design/Construction/Maintenance	1:00 - 4:00 p.m.
A. Towers	
B. Roads	
C. Questions & Answers	
VII. Discussion & Program Evaluation	4:00 - 4:30 p.m.

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ELECTRIC SYSTEM PLANNING

I. INTRODUCTION

System planning is the systematic development of a program which will allow the expansion of an electrical power system in the most orderly and economical manner. Typically, planning is done for periods of five and ten years into the future, but projects requiring large capital expenditures may be studied up to twenty years into the future.

II. LOAD FORECASTING

A. Introduction

Due to the long construction lead times and the high capital expenditures associated with new electric generation facilities, projecting the magnitude of expected electrical demand and energy requirements has become critical. This leads to the first and fundamental step in the facility planning process, the forecast of how much power is required in the future. This allows sufficient time to plan and build additional generation and load management facilities to satisfy the future needs of the consumer. One of the first tasks is to obtain predictions of key forecasting variables. These are factors that have had significant impact on past sales and may be expected to impact future sales.

These key variables include:

Population - The projected population is based on estimates of yearly population by county using births; deaths, and migration rate assumptions.

Economic Activity - The economic indicators used in preparing energy and peak demand forecasts include: California Gross State Product, average income per residential customer, and interest rates. Other economic variables are the Consumer Price Index, and manufacturing employment.

Energy Price/Voluntary Conservation - The impact of changing energy prices is accounted for by explicitly including them into the forecasting procedure. Forecasts of the average electricity and gas prices, for the major customer classes, are input into the models. Voluntary conservation is a response to conservation programs and higher energy prices. Consumers conserve because it is cost effective for them to do so.

Mandatory Conservation/End Use Efficiency - Mandatory conservation is government efficiency standards for residential and nonresidential buildings, and appliances. End use efficiencies allow comparisons between household appliances' energy usage. (i.e., a color TV uses more energy than a black and white set).

Load Management - The peak demand forecast includes the effects of load management programs. The objective of these programs is to shift electricity usage from periods of peak demand, like a hot summer afternoon, to periods with less demand, such as early morning or evening. The result is a more manageable rate of growth and reduced construction and capital expenditure requirements.

Weather - Weather related electricity demand is a function of maximum daily temperatures in nine weather areas representing the Edison service territory, population in these weather areas, the number of residential and commercial customers, and saturation of residential and commercial air conditioners.

Sales and peak demand are sensitive to fluctuations in weather. With hotter than normal summer weather, which occurred in 1967, 1971, and 1981, sales and peak demand increase at a faster than normal rate. Conversly, a cooler than normal summer will cause sales and peak to grow at less than the normal rate. Residential and commercial customers show the largest amount of weather sensitivity, while industrial customers show little reaction to changes in temperature.

Thus the entire forecasting process can be segmented into four steps: (1) gather appropriate data; (2) form input assumptions from the data; (3) input these assumptions into a mathematical model which develops weighting schemes and produces a forecast; (4) and ,most importantly, check the results for reasonableness.

Peak Demand - The peak demand forecast provides information on the two major load components, baseload and weather sensitive load. The baseload component represents such things as commercial lighting, residential washing, drying, cooking, television loads, and during working hours the normal demand of office buildings, stores, and continuous industrial operations. Growth is relatively constant and is based on general long-term economic trends. The vari- able load component is principally responsible for the peaking characteristics of the daily load shape because it responds fairly quickly to changes in environmental

conditions; it is more sensitive to seasonal and climatic conditions. As temperatures rise in the summertime, for example, temporary or short duration load in the form of fans and air conditioners are turned on while the level of normal commercial and domestic activity remains relatively stable.

Southern California Edison's forecast of managed area peak demand for 1990 is 15,600 megawatts. This is an increase of about 2,800 megawatts over 1980, which equates to a 2.0 percent annual growth rate.

kWh Sales - The energy forecast is a measure of the expected duration of energy demands and provides three vital pieces of information: (1) input into determining fuel requirements for supplying future generation needs; (2) the type of generation facility required to supply future energy needs; (3) the expected revenues the company can anticipate. The energy forecast is subdivided into forecasts by major customer classifications. These classifications include residential, commercial, industrial, agricultural, public authority, and resale.

Total kWh consumption is forecast to grow from 58.2 billion kWh in 1980 to 70.8 billion kWh in 1990. This is a 2.0 percent annual growth rate in kWh consumption.

B. Load Forecast - Results and Use

The sensitivity of these forecasts to the variables noted earlier can have severe consequences. A high demand forecast for example, may initiate prematurely the planning and acquisition of additional system facilities in order to reliably serve the expected load. On the other hand, underestimating the demand level may result in insufficient system capacity to reliably serve the load.

The severity of these impacts due to forecasting uncertainties accentuates the need to review the forecast regularly. With these reviews, assumptions can be revised or refined to more accurately reflect changing conditions. The long-range forecast (20 years) is done annually, with semi-annual updates, if possible. Forecasts of near-term requirements are reviewed quarterly to maintain close contact with changing economic conditions, developments in regulatory proceedings, and revenue requirements. With the completion of the future energy requirements forecast, the planning process next looks at how the power will be provided -- generation planning.

III. GENERATION PLANNING

A. Introduction

In developing the forecast of future demand and energy requirements, the need for additional generation resources is the primary consideration. Not only must the generation resources be adequate to meet the projected peak demand, but to serve the load reliably and efficiently. In order to do this, generation facilities must be planned as to primary use, lead time for construction, construction and operating costs, fuel requirements, and available siting. Each of these factors is weighed in selecting the best suited generation resource, both as to the system needs and compatibility with the surrounding environment.

B. Procedure

The first step in the generation planning cycle is to review the yearly peak load and energy requirements and compare those requirements with the existing generating capacity plus the planned generation for which firm commitment has been made. If it is determined that the planned capacity is insufficient to meet Edison's requirements, alternative solutions must be analyzed on the basis of time requirements, generation mix, system reliability, service efficiency, construction and operating cost, fuel requirements, regulatory and environmental constraints, and available siting to select the best generation resource to fill the need.

The factor of time is very important in the selection of a generation resource as can be seen in the combined lead time for regulatory approval and construction for the various types of plant. Typical combined lead times are: combined cycle (6-7 years), coal-fired (8-10 years), and nuclear (13-15 years).

The different characteristics inherent in the various type of generation facilities necessarily result in detailed analysis to determine the optimum generation mix to meet the load demands. Traditionally, generation resources have been divided into three basic classes, base, intermediate, and peaking units, with each class of generation having a different responsibility of meeting the total load. Recent technology has introduced new generation resources which do not fit into any of the three traditional generation classifications. These new resources include such renewables as solar, wind, geo- thermal, and cogeneration. Careful analysis is now being done on how to best integrate these new generation resources into the generation mix.

Base load resources include coal-fired plants, nuclear plants, and base hydro. Base load generation is typically a high capital investment resource with low fuel costs.

Intermediate duration resources include oil and gas--fired plants, combined-cycle plants, and some hydro. Intermediate duration resources typically require a lower capital cost for construction than base load units, but require relatively high cost fuel.

Peaking resources include combustion turbine units, hydro, and short-term contractual agreements. Typically, peaking resources are low energy resources with startup times in the minutes. These units are utilized mainly for short-durations during peak or emergency conditions.

Southern California Edison's objectives in the eighties will be to install base load generation as soon as it can be licensed, purchase power from other utilities as it becomes available, install and purchase power from renewable generation sources, reduce oil-fired generation, and to avoid the use of the fuel-expensive peaking units whenever possible. Also, load management and conservation programs are being pursued to reduce the amount of new generation which will be required.

C. New Generation Resources

Edison's generation resources are expected to increase from 15,592 MW in 1981 to approximately 18,360 MW in 1990. Thirty-six percent of these new generation facilities will consist of renewable and alternate energy sources. The present goals are 140 MW of windpower, 375 MW of geothermal, 290 MW of solar, 55 MW from fuel cells, 740 MW of hydroelectric generation and 500 MW of co-generated power from its customers. The remaining 64% of this increase in capacity will come from nuclear resources, and power purchase contracts and is required for growth in customer loads, the retirement of older generation units, termination of purchase power contracts, and to reduce the dependency on oil.

The SCE Company goal is for 140 MW of wind capacity additions by 1990. Because of the variability of the wind resource, 560 MW of wind machines will be needed to supply the 140 MW of firm capacity.

Edison's goal is to add 375 MW of geothermal resources by 1990. These resources are liquid dominated geothermal and are planned for the Imperial Valley. Edison

currently has three major projects: the first at Brawley, the second at Salton Sea, and the third at Heber.

By 1990, Edison's goal is for the addition of 290 MW of solar resources. Approximately one-third of those resources are projected to be solar thermal facilities while two-thirds are earmarked as photovoltaic and/or thermal applications.

The combination of large and small hydroelectric facilities planned by Edison will add approximately 740 MW by 1990. Cogeneration will add another 500 MW.

Renewable and alternative resources tend to be small in size with shorter lead times characterized by expedited application procedures, limited regulatory jurisdiction, and relatively brief construction periods. The generally short construction periods and small size of renewable and alternative resources, results in less capital being tied up for shorter periods of time.

Other advantages of renewable and alternative resources include reduced oil dependence and reduced environmental impacts, especially air emissions. To the extent that new capacity offsets existing oil and gas-fired generation, each additional megawatt of capacity based on alternative and renewable energy sources reduces Edison's dependence on foreign oil.

Environmental factors are playing an increasing role in siting studies to gain public acceptance. Major environmental objectives incorporated into today's siting studies include: (1) preserving as much of the natural landscape as is reasonably practical; (2) minimizing conflict with present and planned land uses; (3) maintaining acceptable levels of air quality, water quality, and noise; and (4) minimizing the visual impact of the facilities.

IV. TRANSMISSION PLANNING

A. Introduction

The purpose of the transmission system is threefold: (1) serve expanding customer loads; (2) connect generation to load centers; and (3) import purchased power and economy energy as imported coal/nuclear power costs less than oil energy. Considerations which must be accounted for in a transmission plan include:

- Size and location of new generation
- Load growth rates by community and county
- Reliabiity of service and operation
- Existing and future transmission technologies and their availability
- Flexibility of a plan to respond to changes in all of these items.

The SCE bulk power system consists of all substation and transmission line facilities which operate at or above 161 kV. This system not only carries power from Edison's generation resources to the local load centers, but is also used for interconnection with surrounding utilities such as LADWP, PG&E, SDG&E, and others.

B. Transmission Planning

The first step in planning the transmission system is to obtain the basic data which is needed to evaluate the existing system. This data includes geographical distribution of the system peak demand, generation resource power inputs, and all intertie power flows between neighboring utilities.

Once the load forecast for the individual source substations has been determined, it and the other input data can be used to model the system utilizing a load flow computer program. The load flow program matches generation to loads for specific system conditions and determines how the generated power flows through the transmission system to the points where it is consumed. The conditions (contingencies) for which the system is modeled are determined by Southern California Edison's Transmission Planning Reliability Criteria. Some of the valuable information provided by the load flow program include ampere loading of each line, percent line loading based on the conductor's thermal rating, the operating voltage at each substation in the network, and the phase angle difference of each station voltage relative to a fixed point in the system. From this data, it can be determined when line overloads will occur and, thus, when existing lines must be reconductored or new lines constructed. Excessive voltage drops can also be determined and the need for a new line or substation identified.

The load flow program, however, only models the transmission lines, steady state load, and steady state generation. In order to study the effect of rapidly changing system conditions on the generators, they must also be modeled. The modeling of the system generators in addition to the transmission network is done with the transient stability program. This program determines

whether the system maintains transient stability for disturbances such as faults, loss of lines, and quick changes of load and generation. This data is necessary in order to plan the system to withstand these emergencies and avoid a total collapse. System stability limits are also vital in planning for new equipment, where such information as the critical fault clearing time is necessary in determining relay schemes, circuit breaker characteristics, and characteristics of generator regulation equipment. Stability studies are also used to determine the maximum allowable power flow on interties with neighboring utilities without compromising system integrity.

When a system deficiency is revealed by the analysis of the computer program output, viable alternatives for correcting the problem are chosen and additional computer simulation of the modified system completed. This additional simulation is to confirm that the alternatives chosen will solve the problem. After the various alternatives have proven to meet the transmission planning reliability criteria, they are reviewed with other concerned departments to eliminate any project which would create a situation whereby other departments could not meet their standards.

The final step is to obtain the construction costs for the alternatives from the appropriate departments and make an economic analysis of each project.

C. Interconnections

Large interconnections provide opportunities for savings to be realized by sharing installed resource capacities and also greatly increases the assistance available to a utility in an emergency situation. The benefits are not without costs however, the result of having tied adjacent utilities together is that problems on or changes to, another utility's transmission system may have a negative affect on surrounding systems. Joint studies with the other utilities are, therefore, required to ensure that the total interconnected system reliabiity is maintained.

The development of large interconnected bulk power systems and the problems they present created the need for an agency to coordinate the efforts and goals of the individual utilities. Recognizing the need for interutility cooperation in many areas of operation and planning, the National Electric Reliability Council (NERC) was formed. NERC is composed of nine regional utility networks throughout the United States. The regional

council in which Edison is a member is the Western Systems Coordinating Council (WSCC), which covers all of or portions of 14 western states and three provinces in Canada. The primary purpose of WSCC is to coordinate interconnected system planning and operation to ensure reliable system operation.

In addition, the California Energy Commission and the California Public Utilities Commission urge interconnections to improve economic efficiency of the state electrical system and to reduce the amount of oil and gas burned in California.

D. Facts and Figures

1. There are four 500/220 kV, four 220/115 kV, and thirty-three 220/66 kV transmission substations served from the bulk power system. Existing plans call for the addition of three substations, one 500/220 kV, one 500/115 kV and one 220/115 kV, between 1982 and 1990.

2. The total miles of 500 kV and 220 kV transmission line in use will increase from 4,256 in 1980 to 4,643 in 1986.

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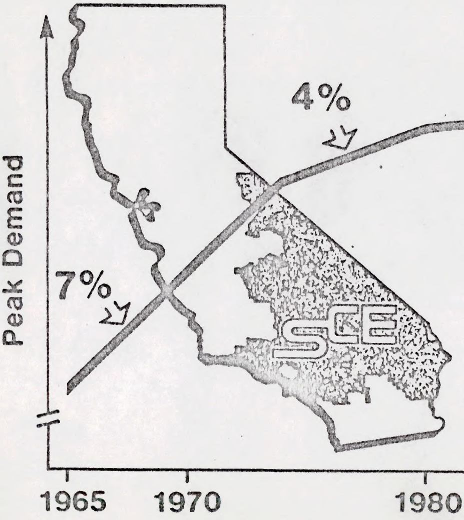
SOUTHERN CALIFORNIA EDISON



- 9 MILLION PEOPLE
- 800 CITIES & COMMUNITIES
- 15,000 MW CAPACITY
- 65 MILLION BARRELS OIL & GAS

Electric System Planning
Fall 1981

WHAT WE FORECAST

- ENERGY SALES - KILOWATTHOURS
- PEAK DEMAND - KILOWATTS
- CUSTOMERS
- MONTHLY PEAK DEMAND AND SALES

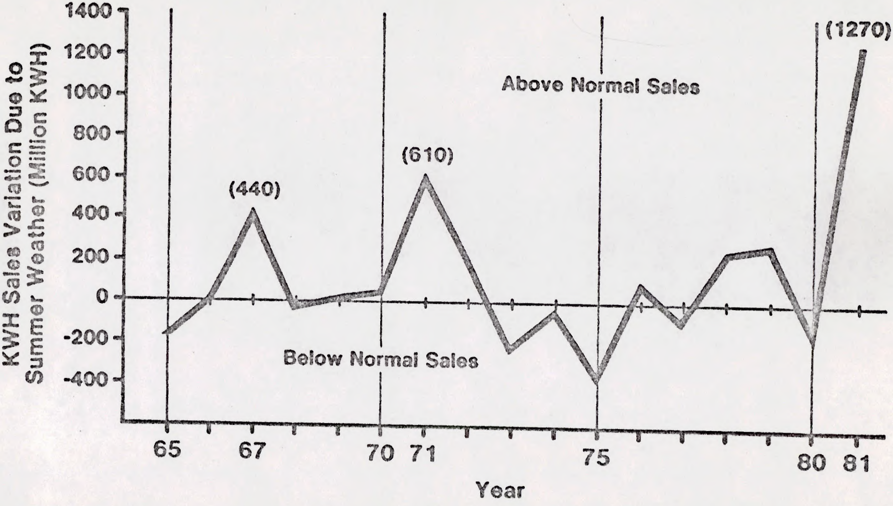
Southern California Edison

KEY FORECASTING VARIABLES:

- POPULATION & CUSTOMERS
- ECONOMIC ACTIVITY
- ENERGY PRICE / VOLUNTARY CONSERVATION
- MANDATORY CONSERVATION / END-USE EFFICIENCY

- LOAD MANAGEMENT
- WEATHER

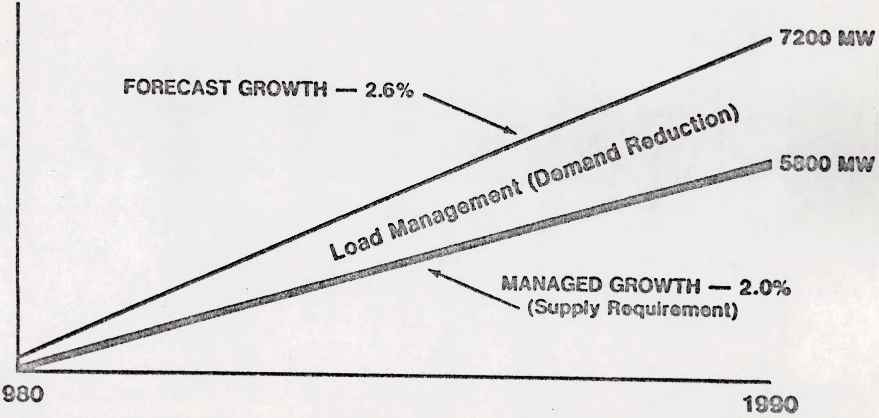
HISTORICAL IMPACT OF SUMMER WEATHER ON KWH SALES



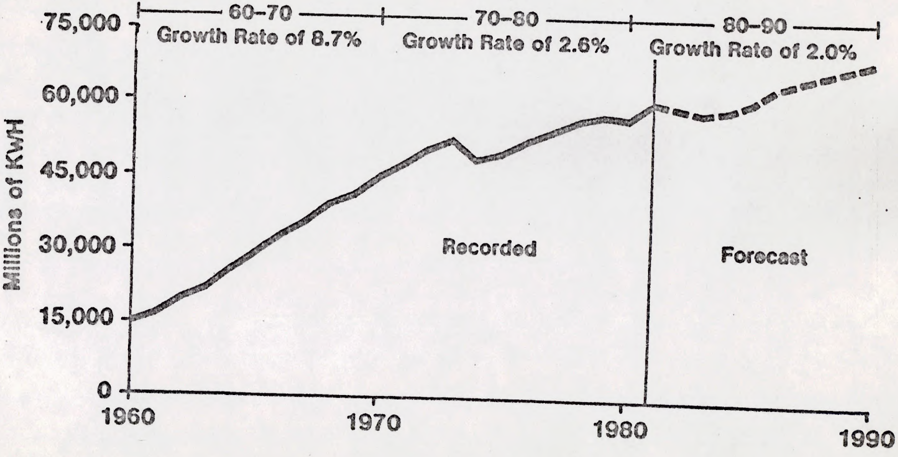
FORECASTING STEPS

- COLLECT DATA
- DEVELOP CONSISTENT SET OF INPUT ASSUMPTIONS
- DEVELOP FORECASTS
- CHECK REASONABLENESS OF RESULTS

SUPPLY/DEMAND FORECAST



TOTAL EDISON KWH CONSUMPTION



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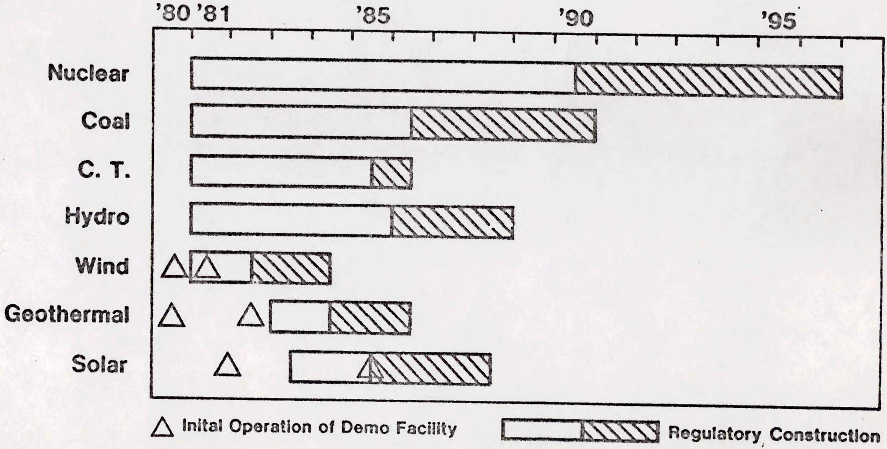
Fall 1981

FACTORS AFFECTING INCLUSION OF PROJECTS IN THE RESOURCE PLAN

- NEED
- LEAD TIME
- CAPITAL COSTS ($/KW)
- DELIVERED POWER COSTS ($/KWH)
- FUEL TYPE
- RELIABILITY
- ENVIRONMENTAL FACTORS
- LICENSABILITY

GENERATION RESOURCE OPTIONS AVAILABLE



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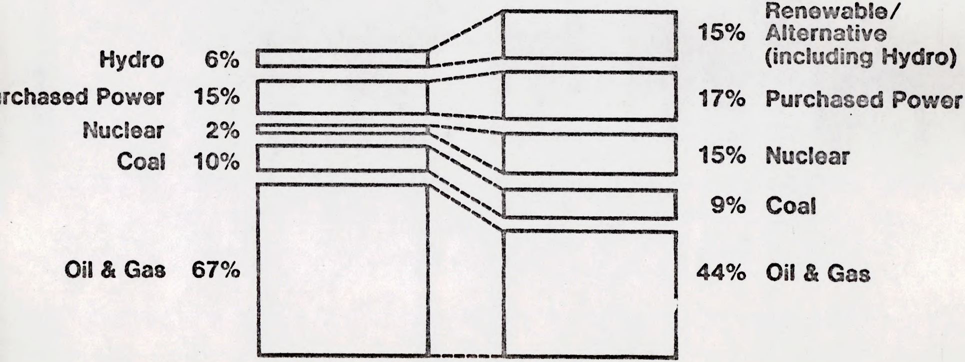
GENERATION CAPACITY MIX

1981 RECORDED
15,592 MEGAWATTS

1990 PROJECTED
18,360 MEGAWATTS



1981–1990 PLANNED RESOURCES

		CAPACITY (MW)
Nuclear		2340
Purchases		1420
Renewables/Alternate		2100
Hydro	600	
Small Hydro	140	
Cogeneration	500	
Wind	140	
Geothermal	375	
Solar	290	
Fuel Cells	55	
Load Management		1400

Southern California Edison Company

Renewable/Alternate Resources

1980–1990 DEVELOPMENT GOALS

RESOURCE	80	81	82	83	84	85	86	87	88	89	90	TOTAL	
						MEGAWATTS							
Hydro													
• Large							200	120	284			604	
• Small Hydro													
— SCE		7	17	25	1							50	
— Customer			1	34	37	10	8					90	
Cogeneration		8	20	26	40	22	75	75	75	75	75	491	
Wind (Firm Capacity)	1*			7	16	16	20	20	20	20	20	140	
Geothermal													
Brawley	5**							52			52	109	373
Salton Sea			9*						52		52	113	
Heber					47					52	52	151	
Solar Generic								10	20	50	100	180	293
Thermal		8***							100			108	
Salt Pond							5*					5	
Fuel Cells								11		22	22	55	

* Initial Operation of Demonstration Unit

** Initial Operation of Demonstration Unit (SCE 5 MW + 4 MW — L.A.D.W.P.)

*** Initial Operation of Demonstration Unit (SCE 8 MW + 2 MW — L.A.D.W.P.)

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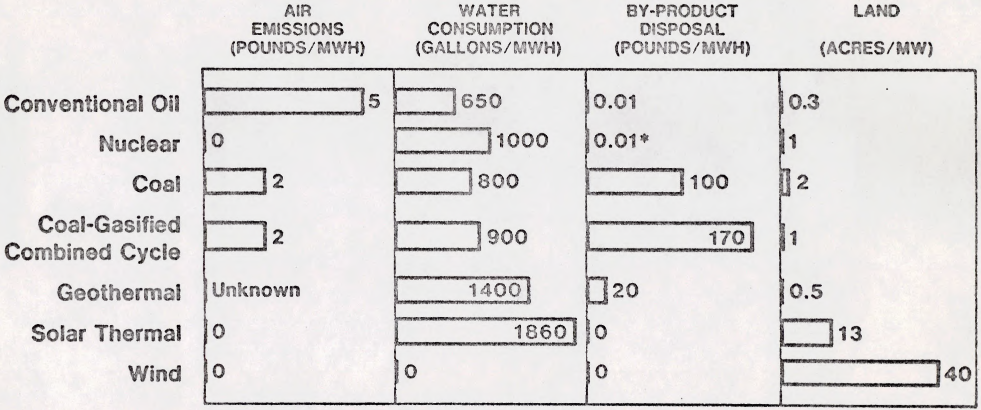
ENVIRONMENTAL IMPACTS



* Radioactive

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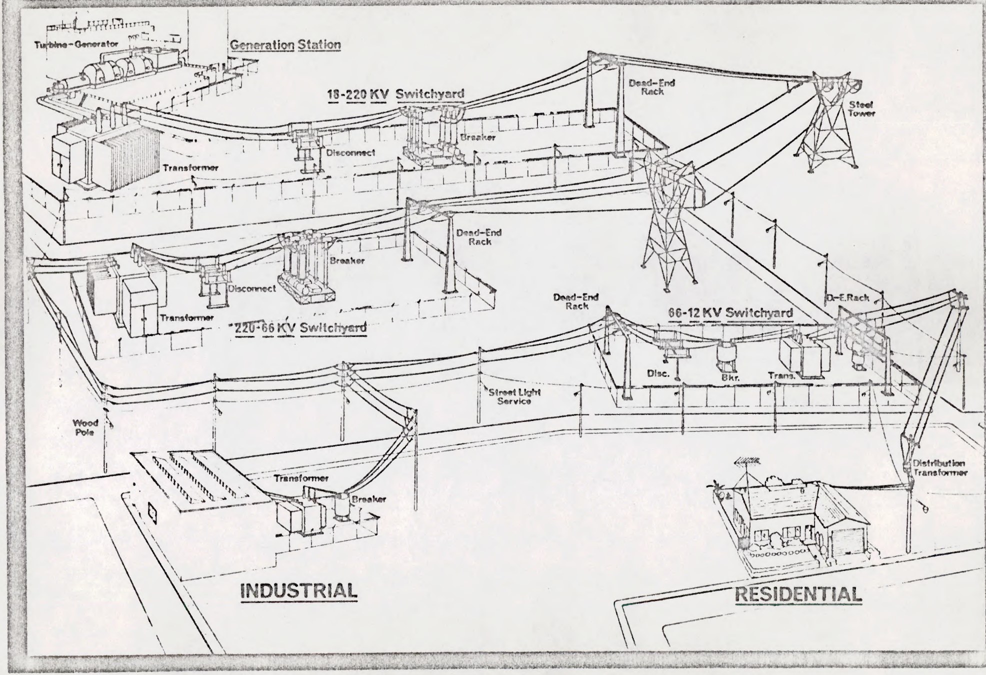
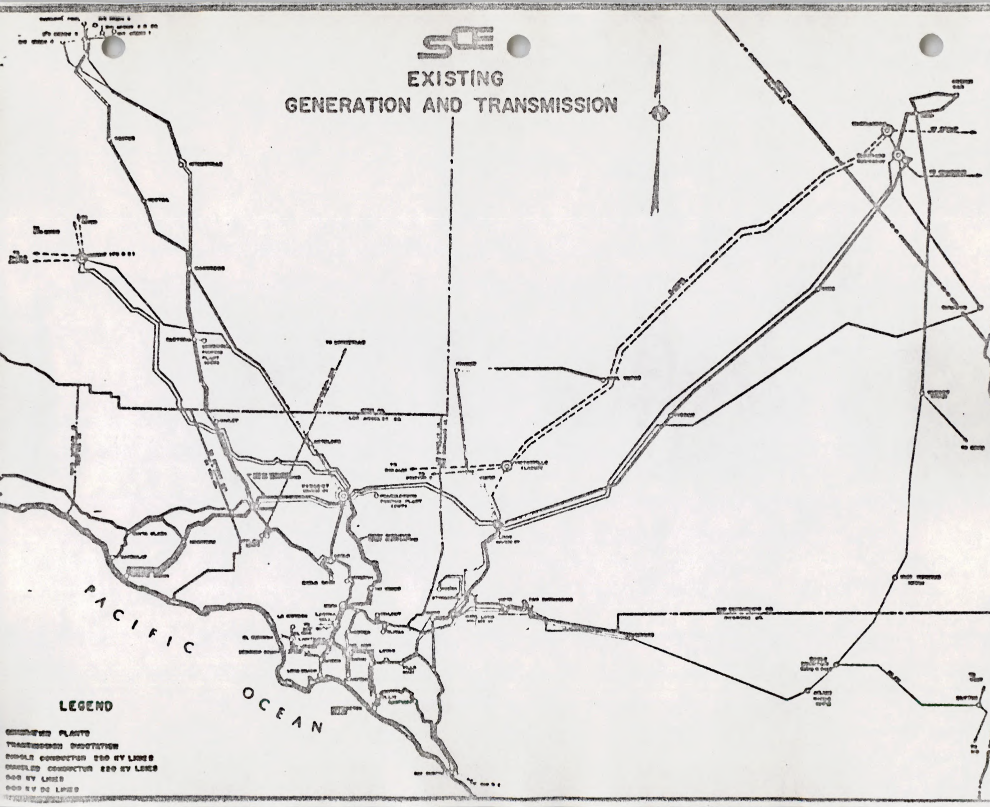
BASIC ELECTRICAL SYSTEM

MAJOR EQUIPMENT

PREPARED BY
ENGINEERING DEPARTMENT



EXISTING
GENERATION AND TRANSMISSION



TRANSMISSION SYSTEM RELIABILITY CRITERIA

DEFINITIONS

Major Load	400MW
Cascading Outage	
Likely Contingency	"N-1"
Unlikely Contingency	"N-2"

CRITERIA

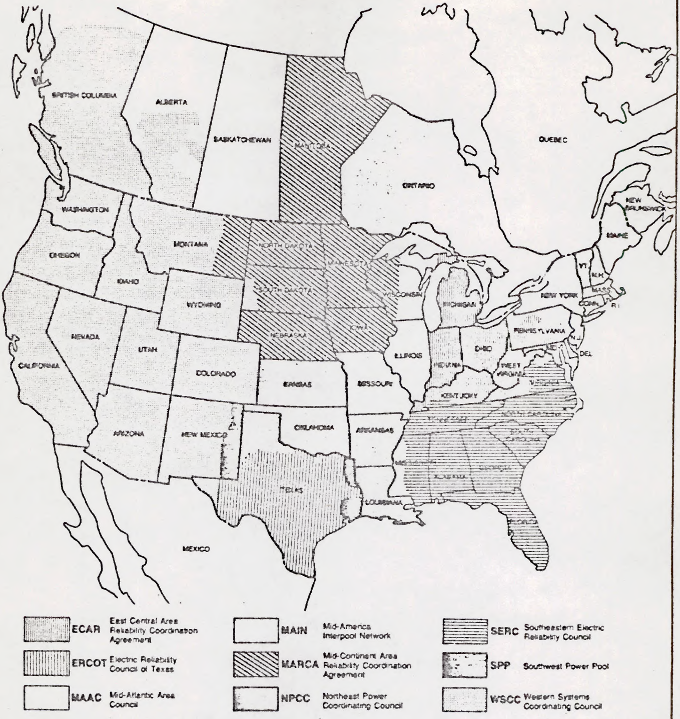
N-1 will not:
- drop load
- load components beyond normal ratings
- cause voltage to depart from schedules (at subtransmission level)

N-2 will not:
- drop major load
- cause cascading outage
- overload components beyond emergency ratings
- cause unsatisfactory voltages

TRANSMISSION PLANNING PROCESS

1. Geographical distribution of load
2. Generation resources capacity and location
3. Intertie power exchanges
4. Load flow analysis
5. Stability analysis
6. Short circuit duty analysis
7. Reliability criteria
8. System deficiencies identified
9. Alternative solutions developed
10. Additional studies confirming solutions
11. Consult other departments
12. Obtain construction costs
13. Economic analysis
14. Weigh all factors: economics, reliability, system performance, operational flexibility, environmental impact, compatibility with future expansion
15. Recommendation: construct facilities or take exception to criteria

NATIONAL ELECTRIC RELIABILITY COUNCIL



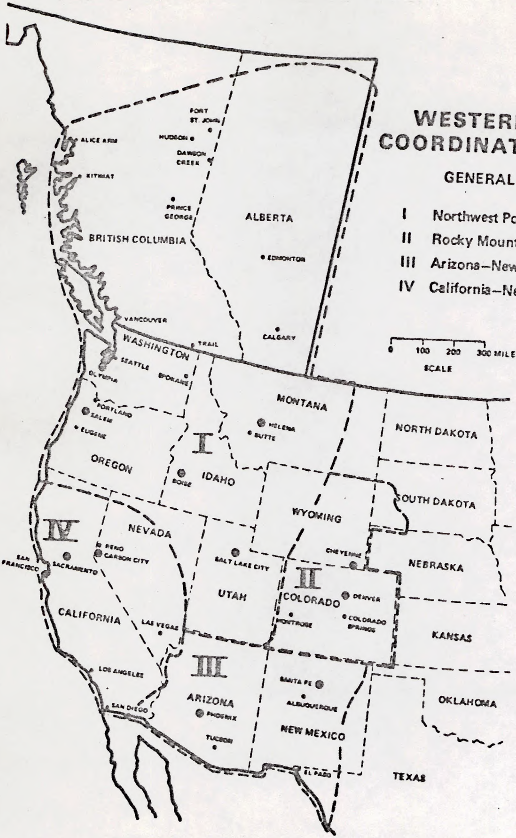
The National Electric Reliability Council (NERC) was formed in 1968 with the stated purpose: "...further to augment the RELIABILITY and ADEQUACY of bulk power supply in the electric utility systems of North America." It consists of nine Regional Reliability Councils and encompasses essentially all of the power systems of the United States and Canadian systems in Ontario, British Columbia, Manitoba, New Brunswick and Alberta.

RELIABILITY and ADEQUACY are two separate but interdependent aspects relating to the bulk power supply system of the electric utility industry in North America. RELIABILITY involves the security of the interconnected transmission network and the avoidance of uncontrolled cascading tripouts which may result in widespread power outages. ADEQUACY refers to having sufficient generating capability to be able at all times to meet the aggregate electric peak loads of all customers and supply all their electric energy requirements.

WESTERN SYSTEMS COORDINATING COUNCIL

GENERAL LOAD AREAS

- I Northwest Power Pool Area
- II Rocky Mountain Power Area
- III Arizona–New Mexico Power Area
- IV California–Nevada Power Area



TRANSMISSION LINE
ROUTE SELECTION

BLM PRESENTATION
1982

TRANSMISSION LINE
ROUTE SELECTION

PROJECT DEFINITION

1. Need for the Project
2. Locate Power Plant Site and Substations
3. Establish Study Area

CORRIDOR STUDY

1. Indentify Problem Areas
2. Public Review
3. Sensitivity Analysis

ROUTE SELECTION

1. Identify Specific Rates
2. Prepare Feasibility Study

FEASIBILITY STUDY
CONSIDERATIONS

GEOGRAPHIC FACTORS

Straightest Possible Route

Type of Terrain/Ease of Construction

Line Visibility

Access Roads - Construction and Maintenance

Location of Highways, Population Centers, Schools, Parks, Monuments, Recreation Areas, Cemeteries, Mining Claims, etc.

Relation to Other Corridors

Proximity to Military Reservations

Proposed Wilderness Areas/National Forests

Land Status/Availability - Federal, State and Private Ownership

Indian Reservations

Existing Land Use/Planned Developments - Highways, Pipelines, Railroads, Master Plans

Community Attitudes

Location of Airports and Airstrips

Cost of Land Acquisition

Cost of R/W Labor - Survey, Drafting, Title, Appraisal

FEASIBILITY STUDY CONSIDERATIONS

ENVIRONMENTAL FACTORS

Biology

- Fauna
- Flora
- Sensitive Habitats

Cultural

- Archaeology
- Historical Sites
- Paleontology

Geology

- Terrain
- Soils
- Seismic

Land Use/Urban Development

- Agriculture and Live Stock
- Population Centers
- Public Health and Safety
- Recreation/Parks/Scenic Areas
- Wilderness/Game Preserve

Other

- Air and Water Quality

THE NEED FOR SAFE TRANSMISSION LINE SEPARATION

Many people and agencies are attracted to the idea of grouping electric transmission lines, and perhaps other point-to-point services such as pipelines, communications lines, and highways, into a small number of relatively narrow corridors. The Southern California Edison Company fully appreciates this point of view. Grouping these facilities in a few narrow corridors minimizes interference with other land uses.

However, we are obligated to warn that, in some cases, the risk of siting transmission lines too close together can be far too great to be accepted. In the next few minutes I hope to give you a basis for evaluating the risk.

Five important facts about the magnitude of the risk:

First, the exact definition of energy is "the capacity to do work". Most of the electric energy generated in the United States is used by industry. When power fails, it is not just the lights and the television that are lost, but the means by which people earn their livings and produce the necessities of life.

Second, in Southern California, electric utility systems are tightly interconnected with other systems hundreds and even thousands of miles to the east and north. A failure in any one of the many interconnected utilities can swiftly throw a heavy burden on neighboring utilities - sometimes with destructive results.

Third, electric transmission lines are no more immune to accidental or deliberate damage or destruction than any other man-made thing. In fact, because of their enormous length, the great weight of the conductors, the height of the towers and their potency as political symbols, they are probably more exposed to loss than other comparable component of our economy.

Fourth, a widespread power loss during a major disaster can severely hamper emergency services like police, ambulance, paramedics, fire control, and communications - and just at the moment when these services are most needed.

And fifth, the goals of maximizing the energy efficiency of transmission systems, and minimizing the area occupied by transmission rights of way, dictate that when it is feasible, electricity should be transmitted over a relatively small number of Extra High Voltage - or EHV - lines rather than a larger number of lower voltage lines.

These risks and the threats they pose to our economy have a large impact on the design of an electric utility grid.

In an electric utility company grid, large transmission voltages are broken down to successively smaller voltages until they reach the average consumer at 110 or 220 volts. A line carrying a larger transmission voltage obviously serves far more customers.

That means that the loss of an EHV transmission line deprives a larger population of the "capacity to do work". It also means that its loss throws a heavier burden on other circuits as the interconnected utility system automatically struggles to maintain service - perhaps a heavier burden than it can bear.

It may seem reasonable to suggest that these are good agruments for building only lower voltage lines. However, there are even more persuasive arguments for Extra High Voltage lines. One is that a few EHV lines can do the job of a larger number of lower voltage lines - meaning less interference with other land uses and less environmental impact.

Also, there is a loss of energy in any electrical conductor - the longer the conductor, the greater the loss. But increasing the voltage to EHV levels reduces this loss. For example, the loss of energy from a 66kV line is approximately 50 times greater than the loss from a 500kV line with the same sized conductors. In these days when the price of fuel makes the cost of nearly all energy exorbitant, we can ill afford to let any go to waste.

After careful analysis, we have arrived at separation guidelines for transmission lines which we believe make EHV efficiency attainable, yet assure continuity of service to our customers. At present we allow no more than two Extra High Voltage lines - that is to say lines carrying 500,000 volts or more - in any single right of way.

We are confident that if a natural or man-made disaster were to sever one of these rights of way, and all of the electrical conductors in it, we could still maintain service to our customers and not endanger the stability of the other western utility systems with which we are interconnected.

If a third parallel EHV line is required, Edison engineers have calculated that we would have to have 2,000 feet of parallel separation between pairs of 500kV transmission lines to obtain an acceptable degree of security. The 2,000-foot parallel separation is roughly equal to the maximum longitudinal distance between towers on one EHV transmission line. When evaluated against most of the hazards we can foresee, this parallel separation appears sufficient to avoid simultaneous loss due to a single event.

Many people are surprised at the number of misfortunes that can befall transmission lines. For instance, in 1973, an airplane struck a ground wire running between the tops of transmission towers in an Edison right of way. The wire was dragged across the conductors of a parallel 500kV transmission line in the same right of way, causing it to fail, also. Thus, we had a simultaneous interruption of two 500,000 volt EHV circuits. In this case, we managed to maintain system stability and avoided any significant service interruptions. But had a third 500kV line been involved with a proportional increase in power flow, the results would have been considerably more serious. This type of accident is much less likely to disturb more than two circuits if

pairs of transmission lines are separated by a distance equal to the longitudinal span between the towers - about 2,000 feet.

Transmission circuits are increasingly exposed to sabotage. In 1974, an extortionist dynamited 11 towers in the state of Washington. One of thes falling towers narrowly missed an adjacent line. When, as in this instance, several lines are close together, it is relatively easy for a saboteur to damage several circuits simultaneously.

Smoke contamination of insulators from bursh fires can also cause transmission service interruptions. The contaminant, carbon, is a very good electrical conductor and when it builds up on insulators to a sufficient degree, a flashover from the conductors to the steel tower structure occurs. We have averaged nearly two fire-related multi-circuit outages per year for the past 11 years in our EHV transmission lines. Typically, these outages last an hour, but they have been known to last 48 hours or longer.

In December, 1980, the entire state of Utah and part of Idaho, Wyoming, and Nevada were blacked out by the severing of a transmission line by a ball of fire which burst from a controlled trash fire at a Utah prison. About one and half million people were affected and hundreds of people reported that electrical equipment was damaged by the outage. All six of Utah Power and Light Company's generating stations were automatically shut down to protect them against damgage. It was more than seven hours before service was restored to all the customers affected.

Brush and forest fires can quickly sweep across many square miles, so Edison separation standards call not only for 2,000 feet of parallel separation, but for separation by firebreaks, riverbeds, mountain ridges, and other natural fire barriers wherever practical. However, 2,000 feet is usally sufficient to let us de-energize a line as the fire passes under it, shifting the power to the unthreatened parallel line. The lines are reenergized as the fire passes or abates.

Wind and ice cause frequent multi-circuit outages in the mountainous parts of Southern California. When ice forms on the lines, the additional weight of the ice combined with horizontal stress caused by wind, can sever the lines. On New Years Day 1973, wind caused an eight-hour overlapping outage of two 220kV lines. A 22-and-a-half hour overlapping outage of a 500kV line and a 220kV line was caused by wind and ice in 1975 and, for one hour, another 200kV line was also out of service.

Lightning storms are routine threats to a power transmission system and the design of such a system must take into account such threats. For instance, in the summer of 1980, a storm which appeared rather small was intense enough to cause numerous brushfires in the Yucca Valley area and to affect 19,000 Southern California Edison customers directly.

In Agust, 1981, a lightning strike on a 500kV line running between Arizona and Nevada caused a series of power outages throughout much of California, Arizona, and Nevada. These out-

ages, which lasted for periods of six to twelve minutes, caused a total of 4,586 megawatts of customer load to be interrupted.

Many of these storm-related outages occur in the hottest part of the summer, when people are most dependent on air-conditioning and when generating and transmission capacities are strained to the utmost.

No fewer than seven 500kV towers - part of the vital Pacific Intertie connecting Southern California with the Northwest - were toppled by high winds in the San Joaquin Valley in 1977. Two of the towers went down because nearby towers fell into them. Three circuits were still out of service more than a week later. Fortunately, at the time of this incident, Southern California was not relying as heavily on power deliveries from the Pacific Northwest as it usually does.

On May 15, 1980, we had another example of the exposure of electric utility systems to electrical storms. On that date, an area of more than 43,000 square miles, and more than 160,000 customers served by the Sierra Pacific Power Company in the Tahoe-Reno vicinity, lost power for as much as two hours. The interruption was caused by two lightning strikes on the Trans-Sierra Intertie - which at that moment was importing 45 percent of the power being consumed in the area - followed an instant later by third lightning hit on a 200kV line serving Tahoe-Reno.

When the intertie was severed, the load was far too great for the local generating units then operating, and the system instantly and automatically began tripping large segments of consumers off the line. Even this proved insufficient and the generators were shut down automatically to prevent them from being damaged. Thus, substantially all power was lost in the region and was only gradually restored during the next two hours.

It is important to note that Sierra Pacific - like most California utilities - is heavily dependent on imported power and is therefore vulnerable to service interruptions caused by damage to intertie transmisson systems.

California's consumers are particularly vulnerable to disastrous electric service interruptions because of the state's unique geographic, economic, and environmental situation. Most of the state's consumers and producers are concentrated along the coast.

However, the state relies heavily on electricity imported from out of state - mainly from the Pacific Northwest and the states to the east of the Colorado River.

The transmission of energy over these great distances makes it important to achieve the greater efficiency offered by EHV. But EHV also increases the dependence of the state on a relatively small number of long, exposed energy arteries.

This dependence could be avoided if it were possible to build more of our power plants close to the coastal cities. However, California's current stringent air quality regulations and land use restrictions preclude that possibility. Instead, we have to depend increasingly on coal-fired generating stations in Arizona, New Mexico, and Nevada and on hydroelectric generating in the Pacific Northwest.

Since State policy continues to discourage siting of additional power plants close to the consumers, Californians must accept it as a fact of life that we will continue to dangle at the ends of a relatively small number of crucial transmission lines, much like deep sea divers living at the ends of air hoses.

The decision as to whether or not separation is needed to insure that these lifelines cannot be severed by a single event depends on the amount of power transmitted and the number of parallel lines between generator and consumer. The greater the number of parallel lines, the greater the support they provide each other and the less concern we need feel about the loss of any one right of way.

Deciding exactly how much protection must be designed into the system will always be a judgment call and sufficient flexibility has been built into Edison's guidelines to allow for special or unusual circumstances. For instance, criteria too rigid might force adjacent transmission lines up a mountainside, away from a valley right of way, making the line more vulnerable to lightning stikes, winds, and icing.

When we analyze the number of lines to be placed in a common right of way, we assume that Edison's eastern interconnections will be carrying approximately 4,500 megawatts by the year 1990. The loss of more than two of these interconnected lines would result in the loss of all power from the eastern interconnections or about 28 percent of the electric energy serving Edison customers at the time of peak demand.

The shock caused by the sudden loss of transmission capacity would lead to this scenario:

An unstable condition would be produced in generating units throughout the Southwest. This would cause some of them to shut down automatically to prevent damage. Automatic control systems also would open the east-west interties, which would stop the transmission of electricity and protect the generators of the exporting utilities to the east of us.

Generators in the Pacific Northwest would increase their output in an attempt to offset the deficit of eastern power. This would create power surges on the transmission lines between Oregon and California. Automatic protection equipment would open these interties and stop transmission of electricity through transmission lines which are normally carrying 2000 to 2500 megawatts of power to California.

With this loss, the total power available to the State's utilities would drop by 7,000 megawatts.

With a sudden loss of this magnitude, the generators remaining within the State would be unable to handle the load and would begin to slow down. Control systems would quickly sense this as a decline in the normal 60 cycle per second frequency of the alternating current in utility circuits. Automatic controls would cut off blocks of customers, attempting to reduce the load to match the available generating capacity.

Due to the breakup of the interconnected systems, similar blackouts could spread throughout the western United States.

This is called cascading, a condition in which a disturbance in one part of an interconnected network spreads to other parts of the system like falling dominoes, ending in the breakup of the interconnected system into islands, some of which may be self-sufficient because of a nearby generating plant and others of which may be totally blacked out. Islanding usually results in a prolonged service interruption for large numbers of customers. There is also a real possibility that utility system equipment, and electrical equipment belonging to consumers, will suffer severe damage. Restoring service after such a widespread blackout is a very complex process and requires a significant amount of time.

Examples of the consequences of this cascading effect are the great Northeast blackout of 1965, the New York blackout of July 1977, and the blackout in France in December 1978.

The impact of these blackouts caused economic catastrophies to the populations involved. The great 1965 blackout of the Northeast affected 30 million people in an area of 80,000 square miles - more than one and a half times as large as Southern California Edison's service territory.

The 1977 New York Blackout completely shut down the consolidated Edison system, and it was observed that while the initial inconvenience fell on the nine million people living in the metropolitan New York area, the costs of the 25-hour outage spread rapidly to affect state and national economic systems, as well as local entities.

One of the common consequences of a massive and prolonged blackout is a costly breakdown of social order and discipline. In New York, losses from looting, vandalism, and arson rapidly mounted to an estimated $1 billion. Extra police, fire, sanitation, transit, and social services added between $7 million and $10 million to the city's cost of operation.

I believe it can safely be said that the cost of a reliable transmission system is a reasonable price to pay to avoid the possibility of such consequences.

In conclusion, cascading failures are difficult to prevent or control since they can be caused by a wide variety of incidents which are difficult or impossible to anticipate. However, one highly effective preventative measure is the minimum 2,000-foot parallel separation between pairs of EHV transmission lines.

Engineers say the EHV transmission system connecting Southern California to its out-of-state resources is "a reliable and stable system". By this they mean that when a major generating or transmission facility is suddenly lost, our grid is well-engineered to withstand the tendency of the disturbance to cascade through the system.

We at Southern California Edison support efforts to protect our public and private lands. And we think it is important to the public interest that we not gamble with our "reliable and stable transmission system" by sacrificing the standards that have made it so. The stakes are much too high.

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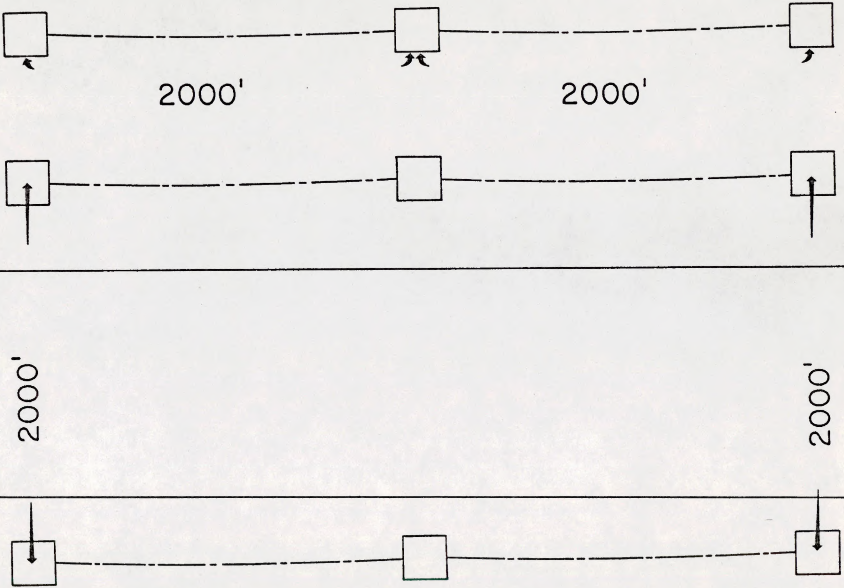

2000'
2000'
2000'
2000'

II. Transmission Line Requirements
Fred R. Klumb, Southern California Edison Company

Fred Klumb is Chief of Transmission Design Engineering for the Southern California Edison Company. He holds a Master of Science in Electrical Engineering from the University of Southern California and is registered as a Professional Engineer in both Civil and Electrical Engineering. He has been involved with transmission related work for 20 of his 25 years with the Company. He has served on the Electric Power Research Institute's Advisory AC Overhead Transmission Task Force for three years, the Electric Research Council's Underground Transmission Steering Committee for two years, Project UHV, and ultra high voltage test facility, Advisory Committee for five years and the Institute of Electrical and Electronic Engineers Transmission and Distribution Technical Committee, Subcommittees and Task Groups for five years.

The Southern California Edison Company has over 10,000 circuit miles of transmission and subtransmission facilities, including 1200 miles of 500kv and 3500 miles of 230kV steel tower lines. As Chief of Transmission Design Engineering, he and his section of engineers are responsible for the engineering and design of these steel tower lines.

II. Transmission Line Requirements

A. The Engineering, Economic, and Environmental Techniques Utilized in Conducting Route Analysis for Future Transmission Systems.

1. Schedule of Activities.

2. Route Analysis

    - o Feasibility Studies
    - o Environmental Impact Reports

        Federal
        State

3. Transmission Line Componenets

    - o Foundations
    - o Structures
    - o Conductor, Insulators and Hardware

B. The Utilization of Higher Capacity Lines to Satisfy Future Demand.

1. Voltage levels and Power Transmitting Capabilities.

2. Engineering and Design Criteria

Transmission Line Requirements (Continued)

C. Environmental Effects of High Voltage, Extra High Voltage and Ultra High Voltage Transmission Lines.

   1. Observed Effects - Historic

   2. Research Activities - Ongoing

D. Transmission Line Construction Techniques and Measures to Mitigate Environmental Impacts.

   1. Helicopter Aided Construction

   2. Placement of Structures and Location of Access Roads

E. Upgrading Existing Facilities vs. Constructing New Lines

   1. Increase Current Capacity

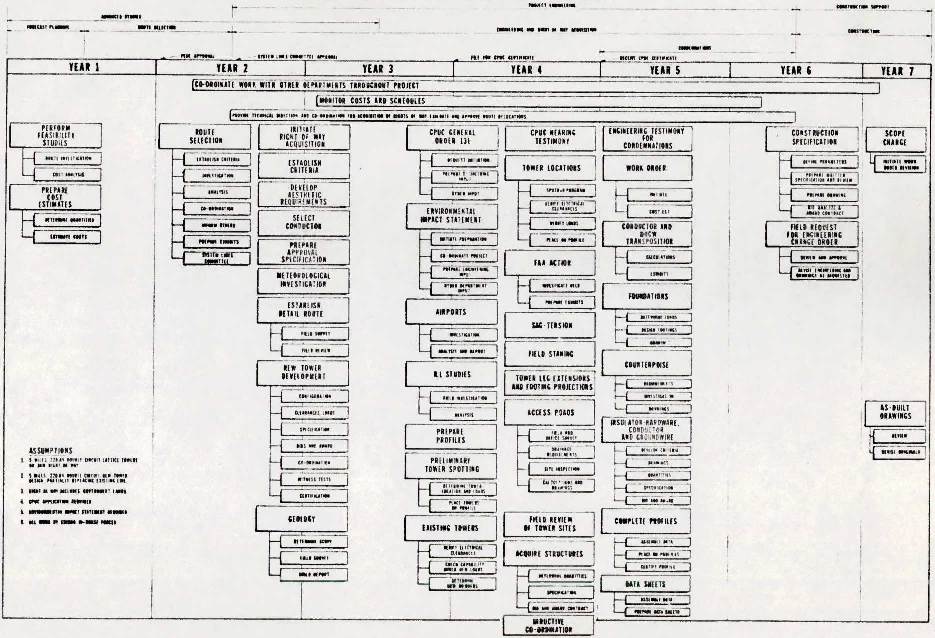
   2. Increase Voltage Level

F. Overhead or Underground Transmission Lines for Electric Utility Systems.

   1. Economic Limitations

   2. Limitations Due to Laws of Physics

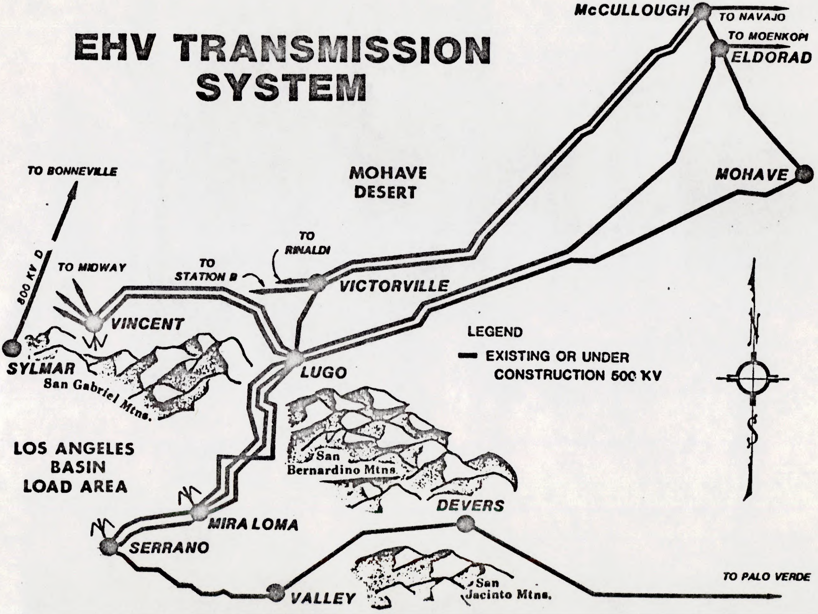
TRANSMISSION LINE PROJECTS-FUNCTION DIAGRAM

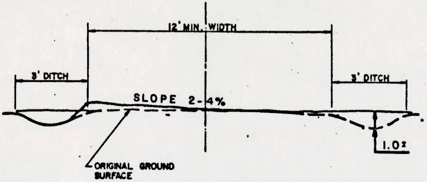


ASSUMPTIONS

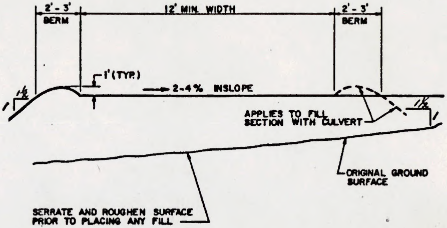
1. 5 MILES 220 KV DOUBLE CIRCUIT LATTICE TOWERS ON NEW RIGHT OF WAY
2. 5 MILES 220 KV DOUBLE CIRCUIT NEW TOWER DESIGN PARTIALLY REPLACING EXISTING LINE
3. RIGHT OF WAY INCLUDES GOVERNMENT LANDS
4. CPUC APPLICATION REQUIRED
5. ENVIRONMENTAL IMPACT STATEMENT REQUIRED
6. ALL WORK BY EDISON IN-HOUSE FORCES

EHV TRANSMISSION SYSTEM

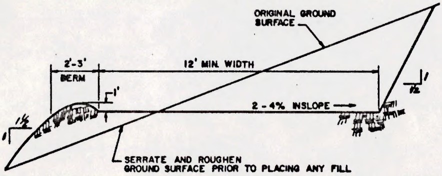




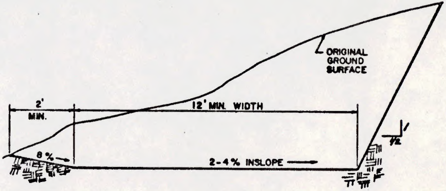
TYPICAL FLAT SECTION (20% MAX. GND. SLOPE)


2'-3'
BERM
12' MIN. WIDTH
2'-3'
BERM
1'(TYP.)
2-4% INSLOPE
1½
1
1½
1
APPLIES TO FILL SECTION WITH CULVERT
ORIGINAL GROUND SURFACE
SERRATE AND ROUGHEN SURFACE PRIOR TO PLACING ANY FILL

TYPICAL FULL FILL SECTION
(40% MAX. GROUND CROSS SLOPE)



TYPICAL FILL-CUT SECTION
(50% MAX. GROUND CROSS SLOPE)

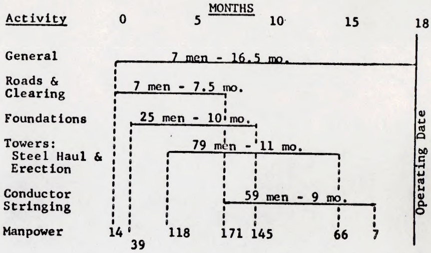


TYPICAL FULL CUT SECTION
(80% MAX. GROUND CROSS SLOPE)

TYPICAL CONSTRUCTION CREWS: 100-MILE T/L

Crew	Supt	Fore-man	Equip Op.	Survey	Mech	Labor.
General (7)	1	2	1-clk	1-guard	2	
Roads & Clearing (7)		1	3		1	2
Foundations (25)		1	4	3		17
	Lineman		Crane Op.	Ground-man		Apprentice
Towers: (79)						
Steel Haul	4	1		1		1
Assembly	20	5		10		15
Erection	11	2	2	4		3
			Sagger			
Conductor: (57)						
Guard Poles	5	1		2		1
Stringing	30	3	1	6		8
Clean-up (2)						2

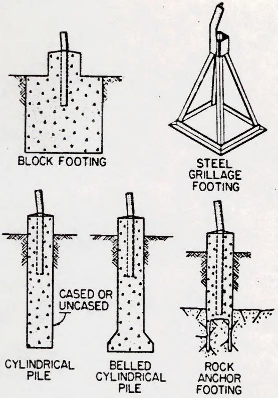
SCHEDULE OF CONSTRUCTION MANPOWER: 100-MILE T/L



PERCENT COST BREAKDOWN FOR TRANSMISSION LINES BY ACTIVITY

Activity	500 kV Sgl. Ckt. Overhead 2B 2156	230 kV Dbl. Ckt. Overhead 2B 1033.5
Engineering	6.0	4.9
Roads	0.7	0.9
Foundations		
Material	1.9	2.2
Labor	2.4	2.3
Tower		
Material	21.7	24.2
Labor	19.5	11.1
Conductor		
Material	36.3	42.6
Labor	11.5	11.8
	100	100
Total $/Mile	$300,000	$250,000

Activity	230 kV Single Ckt. Underground HPOF
Engineering	2.0%
Trench	
Material	1.5%
Labor	11.5%
Pipe	
Material	6.0%
Labor	8.0%
Terminals	
Material	17.0%
Labor	4.0%
Cable	
Material	45.0%
Labor	5.0%
	100 %
	$2,000,000



BLOCK FOOTING

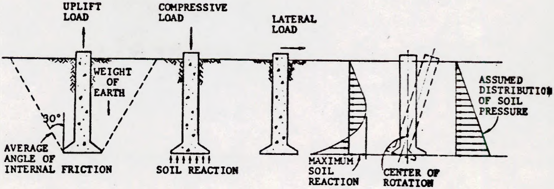
STEEL GRILLAGE FOOTING

CYLINDRICAL PILE

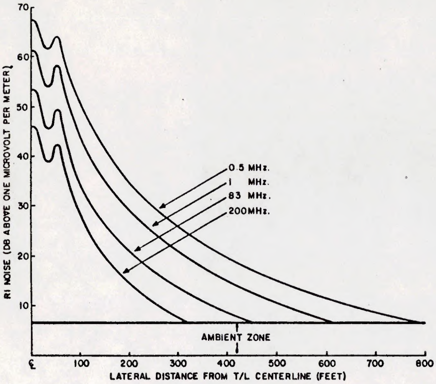
BELLED CYLINDRICAL PILE

ROCK ANCHOR FOOTING

TOWER FOOTING TYPES



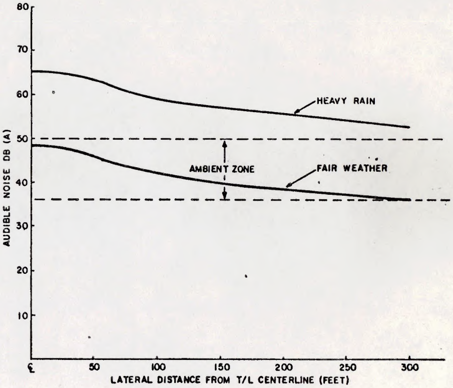
ESTIMATED RADIO INTERFERENCE NOISE



FAIR WEATHER RI
AT GROUND LEVEL

TYPICAL
500KV TRANSMISSION LINE
Southern California Edison Company SCE

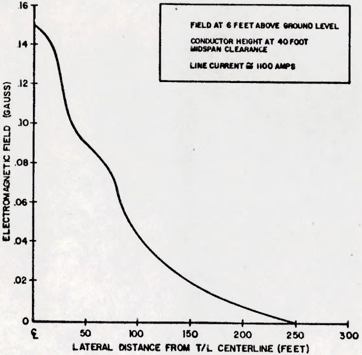
RANDOM AUDIBLE NOISE



RANDOM AUDIBLE NOISE
AT GROUND LEVEL

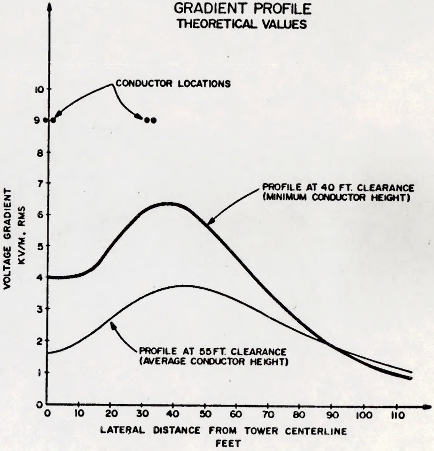
TYPICAL
500KV TRANSMISSION LINE
Southern California Edison Company SCE

ELECTROMAGNETIC FIELD ESTIMATED



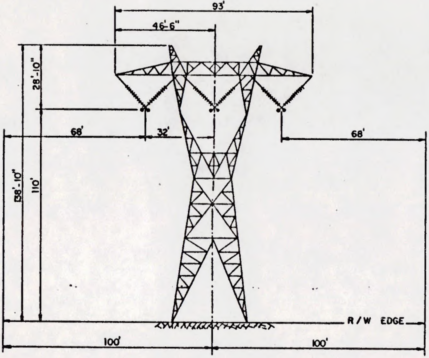
TYPICAL
500KV TRANSMISSION LINE
Southern California Edison SCE

ELECTROSTATIC FIELD GRADIENT PROFILE
THEORETICAL VALUES

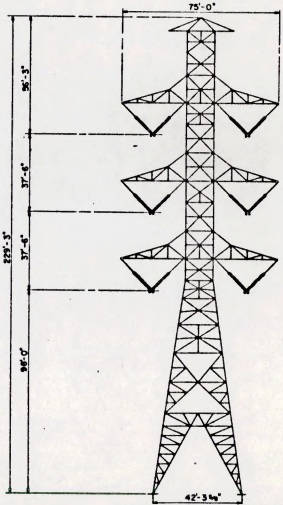


GRADIENT IS AT 6 FEET
ABOVE GROUND LEVEL.

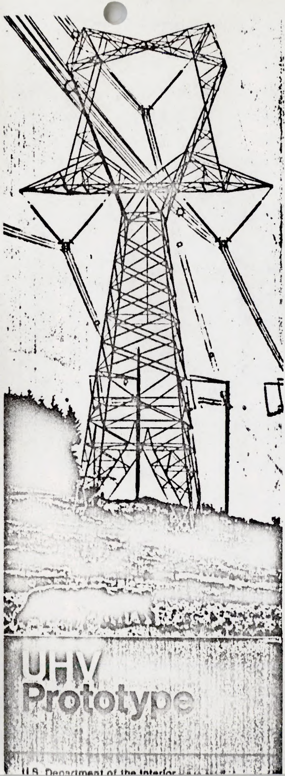
TYPICAL
500KV TRANSMISSION LINE
Southern California Edison SCE



500 Kv Tower



500KV TOWER-TYPE "DHT-S"



UHV Prototype:

Delivering Tomorrow's Electricity

A new generation of electrical power transmission is taking shape in the Santiam River valley just outside of Lyons, Oregon. The tall (200-foot high) towers emplaced at this rural site are strung with bundles of aluminum cables energized with over a million volts of electricity.

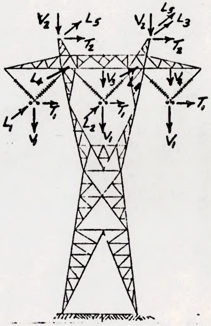
The facility was developed and is being operated by the Bonneville Power Administration, a Federal agency which markets more than half the electric energy and maintains a network of more than 12,300 miles of transmission lines in the Pacific Northwest.

Intended primarily to determine the environmental and economic acceptability of transmitting electric power at ultrahigh voltage (UHV), the BPA Lyons project is a full three-phase installation of a 1.2-million-volt (1200-kilovolt) alternating-current transmission line.

Presently the highest voltage of any a-c line in operation in the BPA system is 500-kV (while the highest voltage a-c line in operation in any network in the country is 800-kV.)

Why UHV?

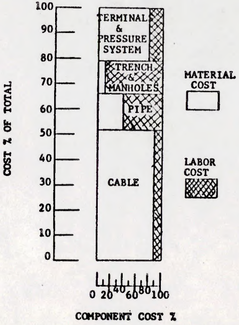
BPA and other utilities throughout the world are making the move to advanced UHV transmission for a number of compelling reasons. When operating in a system at its full power capacity of 8 to 10 million kilowatts, a typical 1200-kV line can move 50 times the power carried by one of the 230-kV lines and 7 times the power carried by one of the standard-capacity, 500-kV lines now operating in BPA's network.

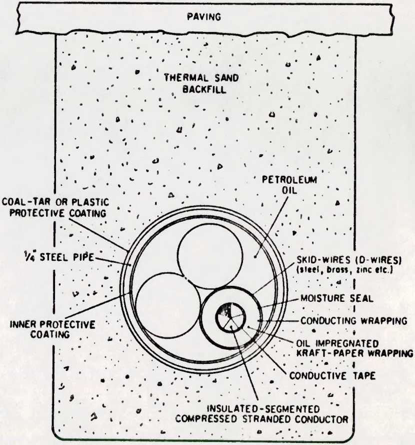


Ldg. Case	T_1	T_2	V_1	V_2	V_3	V_4	L_1	L_2	L_3	L_4	L_5
1	7812	1617	16800	1925	-	-	-	-	-	-	-
2	-	-	-	-	30150	-	-	-	-	-	-
3	-	-	-	-	-	30150	-	-	-	-	-
4	-	-	-	-	-	-	15000	-	-	-	-
5	-	-	-	-	-	-	-	15000	-	-	-
6	-	-	-	-	-	-	-	-	1300	-	-
7	-	-	-	-	-	-	-	-	-	11718	1617

DESIGN LOADS AS APPLIED TO TOWER

COST ANALYSIS
220 KV PIPE-TYPE CABLE SYSTEM




PAVING
THERMAL SAND BACKFILL
PETROLEUM OIL
COAL-TAR OR PLASTIC PROTECTIVE COATING
¼" STEEL PIPE
SKID-WIRES (D-WIRES) (steel, brass, zinc etc.)
MOISTURE SEAL
CONDUCTING WRAPPING
INNER PROTECTIVE COATING
OIL IMPREGNATED KRAFT-PAPER WRAPPING
CONDUCTIVE TAPE
INSULATED-SEGMENTED COMPRESSED STRANDED CONDUCTOR

CROSS SECTION OF A SINGLE-CIRCUIT HPOF PIPE-TYPE CABLE SYSTEM

GLOSSARY OF ENGINEERING TERMS

ANGLE STRUCTURE

A special structure of various designs to permit changing alinement or direction of the routing of a transmission line.

BAY

Space in a switchyard or substation used to terminate or connect transmission facilities.

BENCHING

Local leveling or grading of earth to facilitate design or construction of a structure or operation of equipment.

BUS

A conductor, or group of conductors, that serve as a common connection for two or more circuits.

CABLE SPREADING YARD

An installation comprising all necessary facilities to make the transition from overhead high voltage transmission line to underground high voltage insulated cable.

CAPACITY

The load for which a machine, apparatus, station, or system is rated.

CASCADING

A progressive failure of a power system or part of a system. Failure or loss of a single critical part such as a large, heavily loaded transformer or transmission line will cause the load to shift to other parts of the system in an attempt to supply the loads. If these parts of the system are then overloaded by this increase, the

protective devices will trip, causing these parts to be taken out of service. This progressive loss of transmission capability may cause the entire power system to fail.

CHECK STRUCTURE

A structure in a canal that regulates water surface elevation upstream of the structure flow in canal.

CIRCUIT BREAKER

A mechanical switching device capable of making, carrying, and breaking currents under normal circuit conditions and also for certain abnormal circuit conditions such as those of short circuits.

CIRCULAR MIL

The cross-sectional area of a circle with a radius of 1 mil (1/1000 of an inch).

CONDUCTOR

The wire utilized in electrical circuits to carry current.

2-CONDUCTOR BUNDLES

The common practice of using two wires properly spaced instead of one wire, to reduce electromagnetic effects.

CORONA

The physical phenomena of exciting the molecules of air (or any gas) surrounding a high voltage conductor. At higher voltage, there is an actual spray of electrons into the atmosphere.

CORRIDOR

A corridor is a strip of land used in transmission line planning stages which is sufficient in width to provide latitude in locating one or more transmission lines therein, using topography

and vegetation, in a manner to achieve the greatest harmony with the natural surroundings and the least impact on the environment.

DEAD END STRUCTURE

A special structure to permit attachment of each conductor at full line tension as opposed to suspension structures that only support the weight of the conductor. Dead end structures can be used for tangent and angle structures.

DEMAND

The load at the terminals of an installation or system averaged over a specified interval of time. Example: hourly kilowatt demand.

DISCONNECT SWITCH

A switch in an electrical circuit that enables an operator to conveniently separate a portion of the installation from the remainer of the circuit.

DISTRIBUTION LINES

Low-voltage electric powerlines delivering power to final stepdown transformers at voltages from 2 to 34.5 kv.

DISTRIBUTION SYSTEM

That portion of an electric system used to deliver electric energy from points on the transmission or bulk power system to the consumers.

DOUBLE CIRCUIT

Two separate 3-wire power circuits on the same tower.

ELECTRIC POWER

A term used in the electric power industry to mean inclusively power and energy.

EMERGENCY INTERCONNECTION

An interconnection established to meet an emergency need.

ENERGY

That which does or is capable of doing work. It is measured in terms of the work it is capable of doing; electric energy is usually measured in kilowatthours.

FAULT

A malfunctioning of a transmission line usually due to the short-circuiting of two conductors or live (energized) conductors contacting ground.

FOSSIL-FUEL PLANT

An electric powerplant utilizing fossil fuel, coal, lignite, oil, or natural gas, as its source of energy.

GENERATION

The act or process of producing electric energy from other forms of energy; also the amount of electric energy so produced.

INSTALLED CAPACITY

The total of the capacities as shown by the nameplates of similar kinds of apparatus such as generating units, turbines, synchronous condensers, transformers, or other equipment in a station or system.

INSULATING OIL

A special oil, usually refined from petroleum, used to provide electrical insulation and heat transfer in many types of electrical equipment.

INTERCONNECTION

A tie permitting a flow of energy between the facilities of two electric systems.

INTERTIE

Same as Interconnection.

kv (Kilovolt)

The term for thousand volts.

kwh (Kilowatthour)

The term for thousand-watt-hours (electrical energy).

LIGHTNING ARRESTER(S)

A device installed on power systems to protect equipment from damaging currents resulting from lightning strike.

LINE LOSS

Energy loss and power loss on a transmission or distribution line.

LOAD

This is used in a number of ways: to indicate a device or collection of devices which consume electricity; to indicate the power required from a given supply circuit; the power or current being passed through a line or machine.

MW (megawatt)

One million watts.

NESC

The abbreviation of the National Electrical Safety Code.

NETWORK

A system of transmission or distribution lines so cross-connected and operated as to permit multiple power supply to any principal point on it.

OFFPEAK ENERGY

Electric energy supplied during periods of relatively low system demands as specified by the supplier.

OFFPEAK POWER

Power supplied during designated periods of relatively low system demands.

OVERHEAD GROUND WIRES

Conductors erected along the top of towers and poles to protect insulators and conductors from lightning damage. Sometimes called static or shield wires.

PEAK LOAD

The maximum load consumed or produced by a unit or group of units in a stated period of time. It may be the instantaneous load or the maximum average load over a designated interval of time.

PHASE SHIFTING TRANSFORMER

A device which can control the power flow as desired, on a line operated in parallel with other lines.

PHASE TO GROUND

The difference in electrical potential between an energized conductor of a multiphase power system and the earth.

PHASE-TO-PHASE

The difference in electrical potential between any two energized conductors in a multiphase power system.

POTHEAD

A device that seals the end of an insulated cable and provides insulated egress for the conductor or conductors.

POWER RESOURCES

Installation capable of converting hydro or thermal energy into electric power.

PUMP DROPPING

The curtailing of electric power load in the form of removing electric pumps from the electric system at the supplier's discretion, or in accordance with a contractual agreement.

RADIAL TRANSMISSION LINES

A transmission line supplying electric energy to a substation or a load that receives energy by no other means. The normal flow of energy in such a transmission line is in one direction only.

RELIABILITY

Measure of an electric power system's ability to provide a continuous uninterrupted flow of power.

RIGHT-OF-WAY

A legal right to use a strip of land belonging to others for construction and operation of a transmission line. This right restricts the use of the land to uses that are compatible with the transmission line. In some areas, additional right-of-way would be acquired for operation and maintenance roads.

SERIES CAPACITORS

Devices inserted in a transmission line which make it possible to carry more load without instability than would be the case without them, usually used on long, extra-high-voltage lines.

SERVICE AREA

Territory in which a utility system is required or has the right to supply or make available electric service to ultimate consumers.

SHOOFLY

A temporary transmission line constructed to provide electrical service during the reconstruction or repair of a permanent facility.

SPINNING RESERVE

Generating capacity connected to the bus and ready to take load.

STRUCTURE

A means of supporting the conductor. A structure may be made of many types of material and constructed in various shapes.

SUBSTATION

A single facility at which connections between the various components of a system, such as lines and transformers, are made and the switching of these components is carried out. A typical example is Liberty Substation.

SUSPENSION STRUCTURE

A tower supporting conductors on vertical suspension insulators so that the tower carries only wind and vertical loads.

SWITCHING STATION

See "SUBSTATION." Los Angeles Department of Water and Power describes their facility as "McCullough Switching Station."

SWITCHYARD

A facility that is part of a larger feature such as a pumping plant or powerplant at which connections between the various components of a system are made and the switching of these components is carried out. A typical example is Parker Dam 230 kv switchyard.

TEMPORARY SERVICE

Electric service to a load which exists for a relatively short time. Examples of temporary services are those supplying construction power, carnivals, and street decorations for celebrations.

TRANSFORMER

An electrical device which changes electric energy from one voltage to another at the same frequency.

TRANSMISSION LINE

A facility for transmitting electrical energy at high voltage from one point to another point. Transmission line voltages are normally 115 kv or larger.

TRANSMISSION LINE CAPACITY

The maximum continuous rating of a transmission line. The rating may be limited by thermal considerations, capacity of associated equipment, voltage regulation, system stability or other factors.

TRANSMISSION SYSTEM

An interconnected group of electric transmission lines and associated equipment for the movement or transfer of electric energy in bulk between points of supply and points at which it is transformed for delivery to ultimate consumers, or is delivered to electric systems of others.

UTILITY LINES

Low voltage, usually 69 kv or less, electric powerlines, telephone lines, or other like facilities.

WATT

The unit of power in the International System of Units; equivalent to 1/746 of a horsepower.

WATT-HOUR

Unit of electrical energy, or work, equal to one watt acting for one hour.

WHEELING POWER

The transfer of power through a system without use.

WHEELING SERVICE

An electric operation wherein transmission facilities of one system are utilized to transmit power of another system. Wheeling service may be accomplished by displacement.